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Impact of climatic factors on *Aedes* population and its correlation with the emerging trends of Dengue and Chikungunya in Tricity (Chandigarh, Mohali and Panchkula)

Wats, Meenu and Maansi

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Abstract

Dengue and Chikungunya are the vector borne disease (VBDs) whose viruses are transmitted by infested female *Aedes* mosquito to human beings. The major vector species are *Ae. aegypti, Ae. albopictus* and *Ae. vitattus* whose occurrence and abundance shows a direct correlation with the prevalence of the diseases, especially in urban areas which are found as preferable abodes by these vectors. The present study aims to investigate the correlation between changing climatic conditions (temperature and humidity), the population dynamics of three vector species of *Aedes* mosquito along with the incidences of Dengue and Chikungunya in Chandigarh (U.T.) and its two satellite towns. During the period of investigation (monsoon and post monsoon seasons 2015- 2016) increasing trends in the annual average temperature and humidity was observed, which favored the breeding of all the three species of *Aedes*. The House Index value was found increased from 23.22% to 50% and Container Index from 17.5% and 44% during the period of investigation. The differential population of three species was studied and was correlated with the incidences of Dengue and Chikungunya in the area under study.

For correspondence:

P.G. Department of Zoology, DAV College, Sector-10, Panjab University, Chandigarh, India
Email: **meenuwats@yahoo.co.in**

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Introduction

The mosquito borne diseases mainly hit the human population of tropical and sub-tropical countries because of the naturally available favorable climate for the vectors to flourish. About 2.5 Billion people, throughout the world are at the risk of Dengue (Thangamathi *et al.*, 2014*):* Out of which, Asia contributes 70% of this global burden of which one third (34%) is shared by India (Kristie L. Ebi, 2016*):*

Mosquitoes act as vector for number of diseases to mankind and animals such as Malaria, Japanese Encephalitis (JE), Lymphatic Filariasis (LF), Eastern Equine Encephalitis (EEE), St. Louis Encephalitis (SLE), West Nile Virus (WNV), Yellow Fever (YF), Brain Fever, Dengue, Chikungunya, etc. (Jaswanth *et al.*, 2002) of which India is facing medical and economical threat from five main diseases viz. Malaria, Japanese Encephalitis, Lymphatic Filariasis, Dengue and Chikungunya.

In India the reports of Dengue and Chikungunya are available since 1950 and 1960 respectively but the severity of Dengue has increased manifold in the last two decades and that of Chikungunya since 2006. The National Vector Borne Disease Control Programme (NVBDCP, 2013) had reported that dengue has been endemic in 16 states and UTs since the beginning. The Chikungunya virus seems to be re-emerged in 2006 after a gap of 32 years in India and has reported 18639 of Chikungunya along with 74454 cases of Dengue till 2013 (Cecilia, 2014*):*

Dengue (DENV) and Chikungunya virus (CHIKV) has been reported to be transmitted worldwide by *Ae. aegypti,* acting as the primary vector (Vincent *et al.*, 1998 and William *et al.*, 2002) and *Ae. albopictus* as secondary vector of Dengue and Chikungunya in Asia, Africa and Europe (Gratz, 2004 and Carrieri, 2011*): Ae. vittatus* has also been reported as a potential vector of Chikungunya and Yellow Fever (Mawlouth Diallo, 1999; Kumar *et al.*, 2013 and Ali *et a.l*, 2014*):* In nature DENV maintain itself by human-mosquito-human cycle where *Ae. aegypti* remains preferable host but the mutant forms of *Ae. albopictus* under experimental conditions show equal efficacy to act as the vector of the same virus.

It has been observed that mosquitoes in general breed in wide variety of habitats but the breeding of *Aedes* has been primarily confined to natural as well as manmade containers filled with freshwater (Service 1995 and Banerjee *et al.*, 2013*):* The different species of *Aedes* do show slight demarcation in the selection of their breeding sites. *Ae. aegypti* prefers artificial water containers while *Ae. Albopictus* breed both in manmade as well as natural containers viz. hollow bamboo stalks, tree holes, leaf axils, tanks, pools, streams and discarded and unattended containers (Pemola *et al.*, 2005*): Ae. vittatus* favors pot holes, discarded tires, empty coconut shell, latex collecting containers, abandon earthen pots, rain or irrigated water filled plant pot, plastic container and tank, tree hole etc. for their breeding (Jomon, 2009*):*

Globalization, urbanization, demographic change, inadequate domestic water supplies, along with increasing temperatures and humidity are associated with the spread of the main vectors like *Ae. aegypti*, *Ae. albopictus* and *Ae. vittatus* (Murray *et al.,* 2013 and Thangamathi *et al.*, 2014*):*

This study was undertaken to investigate the various breeding sources and distribution of three species of *Aedes*, role of temperature and humidity in their population dynamics and their correlation with the prevailing cases of

Dengue and Chikungunya in Tricity in 2015-2016 time span.

Materials and Methods

A. Study area (Figure 1.)

The study was carried out in the Tricity Area [Chandigarh (UT), Mohali (Punjab) and Panchkula (Haryana)] from July 2015 to November 2016 (Monsoon and Post Monsoon Season*):* Chandigarh (UT) and its two satellites towns are located near the foothills of the Shivalik range of the Himalayas in northwest India with co-ordinates 30.74°N 76.79°E. Tricity has a humid subtropical climate favoring very hot summers, mild winters, unreliable rainfall and great variation in temperature ranging between 1°C to 46°C over the year.

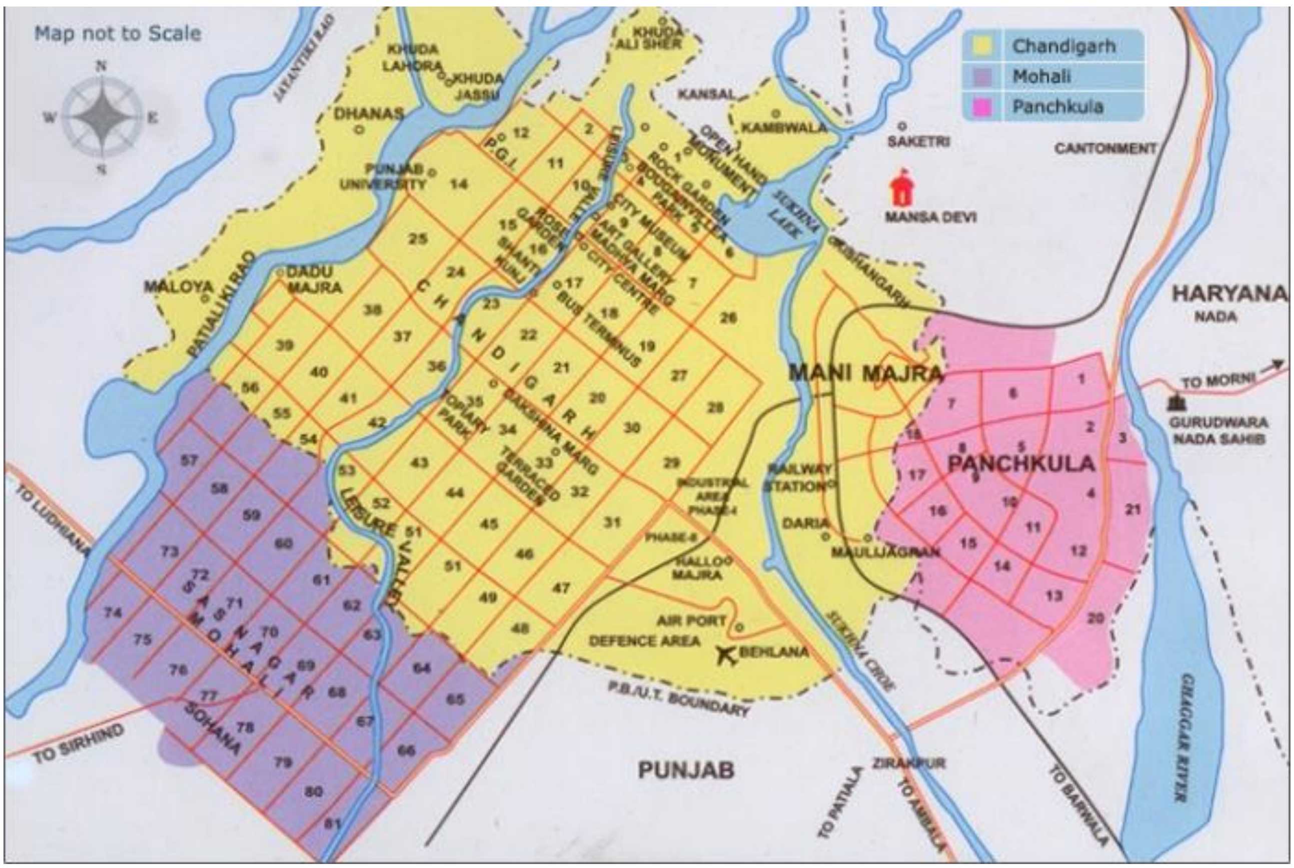


Fig. 1: Study Area

B. Mosquito larvae collection and identification

Larvae of different *Aedes* sp were collected from their potential breeding sites (shown in Fig. 2), using standard larval dipping method. Out of 30 houses which include gardens, streams, residential houses and institutional campuses, total of 200 containers were scanned per year. The larvae were reared in the laboratory to raise them to adult for their identification on the basis of morphological characteristics using various standard keys.

C. Entomological indices

The species composition was estimated as,

(i) House index (HI) = $\frac{number\ of\ positive\ houses}{total\ number\ of\ inspected\ house} \times 100.$

(ii) Container index (CI) = $\frac{number\ of\ positive\ contianers}{total\ number\ of\ inspected\ containers} \times 100.$

(iii) Percent composition (%) = $\frac{number\ of\ larvae\ of\ a\ perticular\ species}{total\ numer\ of\ larvae\ collected} \times 100.$

Fig. 2: Different Breeding sites

D. Collection of data of incidences of Dengue and Chikungunya

The data concerning the number of incidences of Dengue and Chikungunya in the Tricity during the study period has been collected from various journals and media sources like Newspapers, TV channels and magazines.

Results

During the survey, total 30 houses were scanned in a year's time, of which 7 houses in 2015 and 15 houses in 2016 were found as positive for *Aedes*. The house is one unit of accommodation, its surrounding premises and open habitats, irrespective of the number of people residing therein (Tun-Lin W *et al.,* 1995 and Directorate General of Health Services, Government of India 2005*):* Most of the positive sites were found out door viz, botanical gardens, local gardens, institutional areas, in comparison to indoor. It can probably be due to strictness from the local administration for not holding any type of fresh water indoor along with the rising awareness among the residents. The HI value, indicating the percentage of positive houses, was found increased from 23.22% (2015) to 50% (2016*):*

Out of 200 containers 35 were found positive in 2015 while 88 were in 2016. The CI value, which indicates the percentages of positive containers were also found, increased from 17.5% to 44%.

From the present collection three species of genus *Aedes* were identified namely *Aedes aegypti* (Linnaeus), *Ae. albopictus* (Skuse) and *Ae. vittatus* (Bigot*):* Positive site for these species of *Aedes* were found overlapping as well as isolated. Larvae of *Ae. aegypti* were mainly collected from desert coolers, earthen pots and plastic containers while *Ae. albopictus* from both manmade and natural containers like bamboo, tree holes, xerophyte plants pots and *Ae. vittatus* larvae were found breeding in earthen pots filled with rain water in institutional campus and gardens.

Total population of three species of *Aedes* was found to increase more than three times (3.26) in a year's span. In 2015 the dominance of *Ae. aegypti* was found over other two species. In 2015 collection, 79.11% of the total larvae collected belonged to *Ae. aegypti*, 12.44% to *Ae. albopictus* and 8.44% to *Ae. vittatus* while in 2016 the population of *Ae. albopictus* and *Ae. vittatus* were found increased (22.2% and 24.79% of the total respectively) while that of *Ae. aegypti* was found on decline (52.99% of the total) from the previous year but still it remains a predominant species among the three. (Table 1 and Figure 3)

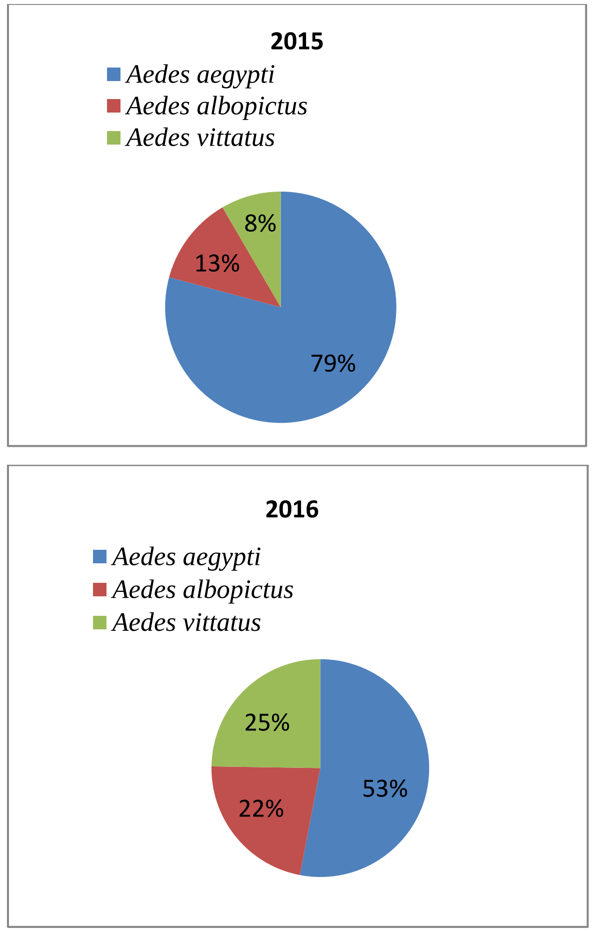


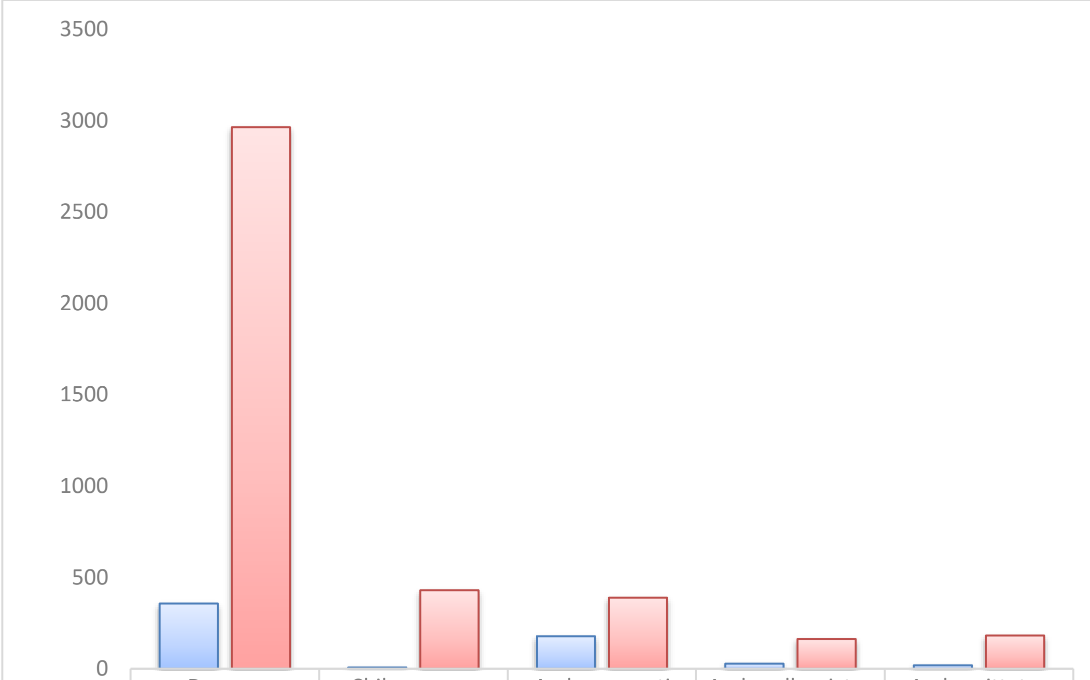
Fig. 3: Percentage composition of three species in 2015-16

The differential pattern of breeding rates amongst three species shows that *Ae. aegypti* population increased 2 times, *Ae. albopictus* 6 times while *Ae. vittatus* 10 times (Figure 4) during the survey period.

The year 2016 has witnessed an increase in temperature, humidity (Fig. 5) along with flared up numbers of Dengue and Chikungunya cases (Fig. 4) from Tricity in comparison to 2015.

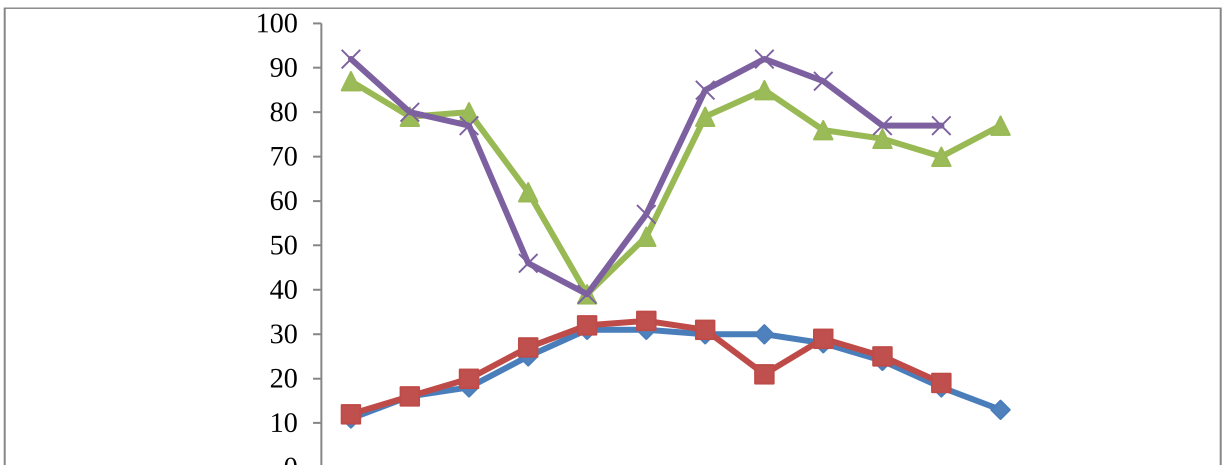
Aedes sp.	2015 (n=225)	2016 (n=734)
Ae. aegypti (Linnaeus)	178 (79.11%)	389 (52.99%)
Ae. albopictus (Skuse)	28 (12.44%)	163 (22.2%)
Ae. vittatus (Bigot)	19 (8.44%)	182 (24.79%)

Table 1. Frequency of *Aedes* larvae collected from Tricity during 2015-16.



	Dengue	Chikungunya	Aedes aegypti	Aedes albopictus	Aedes vittatus
2015	357	7	178	28	19
2016	2964	430	389	163	182

Fig. 4: Comparison of number of Dengue and Chikungunya cases with population dynamics of different *Aedes* species collected during 2015 and 2016.



	January	February	March	April	May	June	July	August	September	October	November	December
2015(Temperature)	11	16	18	25	31	31	30	30	28	24	18	13
2016(Temperature)	12	16	20	27	32	33	31	21	29	25	19	
2015(Humidity)	87	79	80	62	39	52	79	85	76	74	70	77
2016(Humidity)	92	80	77	46	39	57	85	92	87	77	77	

Fig. 5: Monthly variation of Temperature and Humidity during 2015 and 2016

Discussion

In the present investigation, the increasing trends in the population dynamics of *Aedes*, temperature, humidity and the cases of Dengue and Chikungunya in one year time span were observed. It was noticed that increase in climatic factors like temperature and humidity favors the breeding of various vector species of mosquitoes especially of *Aedes* which are responsible for two major VBDs i.e. Dengue and Chikungunya. An abrupt increase in the population of *Ae. aegypti, Ae. albopictus* & *Ae. vittatus* has been reported during the study period. The hot and humid climate leads to the increase in their breeding rates and make a particular area susceptible to these VBDs. Van Lieshout *et al.* 2004 also observed climate as one of the principal determinant for the distribution of VBDs. Few more studies have also reported the vital role of temperature in influencing the breeding rate of mosquitoes and their tendency to transmit Dengue (Erickson 2012 and Alto 2013*):* Bhatt *et al.*, 2013 and Estallo *et al.*, 2015 has also correlated hotness and humid environment with elevated dengue risk in Argentina.

Post monsoon or hot and humid season was observed as the most potential time for the incidences of the two VBDs, probably due to the filling up of empty reservoirs by the preceding month's rains. Pandya 1982 also reported the rise in vector population and Dengue infections during and after rainfall.

Aedes occurrences along with their density are the two main biotic indicators for determining the risk of Dengue and Chikungunya in any locale. In the present study, the population of *Ae. albopictus* and *Ae. vittatus* were found more elevated in the total population in comparison to that of *Ae. aegypti*. Kaur (2014) also observed the same displacement by *Ae. albopictus* over *Ae. aegypti* in Chandigarh and correlated it with the intense competition between the two species for food, habitat and environment. The 10 times increase in *Ae. vittatus* population was also found as one of the major reason for the outbreak of Chikungunya in the tricity in 2016 as *Ae. vittatus* has been certified it as a potent vector of Chikungunya by Diagne *et al.*, 2014 by isolating CHIKV from *Ae. vittatus.*

According to Sharma *et al., (*2005) the high value of the CI are found to show close association with cases of Dengue in India and the present survey also shows similar observation in 2016 in the tricity area. More larval densities and cases of Dengue and Chikungunya were reported from the outskirt of the Chandigarh which happens to be municipally more neglected and densely populated in comparison the its core sectors. More use of air conditioners in comparison the desert coolers in the central sectors were found another reason of lesser cases from these sectors. Same type of decreased vector-human interaction due to lesser water containers availability was also reported by Khormi and Kumar 2012. Educational institutes were also found to be the victim of mosquito breeding sites due to neglected behavior of authorities and students towards this issue.

In totality human negligence and changing climatic conditions in the tricity urban area led to increase in population of *Aedes* sp. and high number of Dengue and Chikungunya cases in the UT Chandigarh & its two neighboring towns; Mohali and Panchkula in 2016.

Conclusively, the temperature and humidity were found influencing *Aedes* population whose repercussions came out as the more incidences of Dengue and Chikungunya. The potential roles of *Ae. albopictus* and *Ae. vittatus* as equal potent vectors of these two diseases are also put forward.

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